Sealing ring and sealing ring arrangement

The invention relates to a sealing ring for sealing two components moving relative to each other, particularly as a rotary shaft seal or piston ring, with a radially internal or external sealing surface that can be brought into contact with one of the components to form a seal against a fluid medium, where, to the side of the sealing surface, the sealing ring displays a pressurizing surface to be pressurized by the fluid medium and, on the opposite side, a supporting surface to the side of the sealing surface for positioning against a groove flank of a component accommodating the sealing ring. The invention further relates to a sealing ring arrangement with a sealing ring according to the invention.

Sealing rings according to the invention are particularly used as rotary shaft seals to seal a shaft against a shaft guide, which can also constitute a housing, or as piston rings.

Both the sealing ring and the groove receiving it mostly display a rectangular cross-section in the fields of application mentioned. In this context, one of the groove flanks serves to support the sealing ring and is a sealing surface at the same time. In various fields of application, sealing against the component to be sealed, with which the sealing surface of the sealing ring can be brought into contact, is accomplished by external pretensioning of the sealing ring, or by pressurization of the sealing ring by the respective fluid medium, by

which the sealing ring is pressed against the supporting groove and the component to be sealed.

The incorporation of rectangular groove cross-sections in the respective component is, however, relatively complex on the one hand, since it entails notch effects, which are to be avoided for many applications, if at all possible. Reducing the notch effects by means of suitable groove geometries is complex and, at the same time, either reduces the wall thickness of the sealing element, and thus its sealing effect, or results in deeper grooves. To achieve sufficient tightness, it is often even necessary to elaborately machine the groove flanks by grinding or other work steps. In the case of sealing rings with a rectangular cross-section, and thus corresponding grooves in the respective component, one particular disadvantage is that, owing to the respective available space, the sealing rings can often not be provided with the necessary heights or widths that would be required for sufficient tightness. This is particularly the case if the sealing rings are supportively, or also essentially exclusively, pressed against the sealing surfaces by the pressure of the fluid medium, since adequately dimensioned pressurizing surfaces on the sealing ring can then often not be provided to a sufficient extent owing to the prevailing available space. If sealing against non-wear-resistant materials is required, alternative measures have to be taken, such as lining the housing bore with steel sleeves.

Moreover, with conventional sealing ring arrangements, the often confined space available causes problems as regards adapting the design of the sealing ring arrangement to different requirements or fields of application, since changing the groove depths is occasionally subject to narrow limits.

The object of the invention is to create a sealing ring and an associated sealing ring arrangement that guarantee great tightness with little manufacturing effort, and that can be adapted

to different requirements profiles with a minimum of design-related effort.

According to the invention, the object is solved by a sealing ring on which the pressurizing surface or the supporting surface, or the pressurizing surface and the supporting surface, are inclined relative to the sealing surface of the sealing ring and enclose an angle of < 90° towards it, where the sealing ring is capable of compression or expansion in the radial direction, depending on the arrangement of the sealing surface, especially under the intended pressure of the fluid medium during operation of the associated machine or device.

Due to the inclination of the pressurizing surface and/or the supporting surface towards the sealing surface of the sealing ring, the contact force of the supporting surface against an associated supporting flank of the groove accommodating the sealing ring, and the contact force of the sealing surface against the respective component to be sealed, can, with a given lateral pressure of the fluid medium on the pressurizing surface, be broken down by the corresponding geometrical resolution of forces, and the respective contact force against the corresponding surfaces of the sealing ring under certain operating conditions can be set by selecting different angles between the supporting surface or pressurizing surface and the sealing surface. At the same time, the contact forces, and also the resultant radial tension of the sealing ring, change in the required manner in response to changes in the pressure force of the fluid medium resulting from varying operating conditions of the respective machine. Furthermore, the pressure force of the fluid medium simultaneously centers the sealing ring in the respective receiving groove. Moreover, the associated groove flanks, particularly the supporting flank and the pressure-side flank of the groove, can also be manufactured more easily owing to their inclined position, thus avoiding the scores that often occur when withdrawing the respective tool during the manufac-

ture of vertical groove flanks. Furthermore, the groove flanks are more easily accessible for subsequent machining operations, such as grinding and the like.

The supporting surface and/or the pressurizing surface are correspondingly inclined relative to the central longitudinal axis of the sealing ring. In this context, the sealing surface is partly or entirely arranged concentrically to the central longitudinal axis of the sealing ring, and is preferably designed as the surface of a cylinder that can be a radially external or internal boundary surface of the ring.

In particular, however, it is also possible, on account of the inclined position of the pressurizing surface and/or the supporting surface, to achieve a substantially larger contact area between the sealing ring and the shaft, and thus also a significantly longer flow path for leaks, compared to a corresponding rectangular ring with the same groove depth.

Depending on the field of application, the fluid medium can be a gas or a liquid, such as the pressurized oil or grease of an automatic transmission or another device, although the fluid medium can also be any other liquid, especially an aqueous phase, a gas or the like, particularly when using the sealing ring in reciprocating pumps.

The pressurizing surface and/or the supporting surface are preferably each designed at least partly, or completely, as the lateral surface of a truncated cone, this resulting in flat contact with the respective supporting flank or pressure-side flank of the groove at all times, also upon radial expansion/compression of the sealing ring. The respective lateral supporting and/or pressurizing surfaces each surround the sealing ring over its entire circumference.

For many fields of application, it has proven advantageous if

the pressurizing surface and/or the supporting surface enclose an angle ALPHA of < 80° to 75° and > approx. 20°, preferably an angle of approx. 30° to approx. 60°, particularly preferably an angle of approx. 45°, towards the sealing surface, meaning the angle enclosed with it in each case. Correspondingly, the pressurizing surface and/or the supporting surface can enclose an angle of 90° - ALPHA with the central longitudinal axis of the sealing ring. For many applications, the pressure force of the fluid medium is, as a result, capable - acting alone or supportively - of achieving a sufficient sealing effect by pressing the respective supporting or sealing surfaces against the associated component, and reliable centering of the sealing ring in the groove.

The areas of the pressurizing surface and/or the supporting surface of the sealing ring with the form of a truncated cone preferably follow on laterally, at least almost directly, from the sealing surface, thus determining the contact forces on the supporting flank and the corresponding component in the area of the sealing surface. Where appropriate, the above-mentioned surfaces each follow on from the sealing surface apart from a concavely curved, arc-shaped transitional area. If the respective areas with the form of a truncated cone extend virtually over the entire thickness of the sealing ring, the latter displays an essentially V-shaped cross-section. Where appropriate, the areas of the pressurizing surface and/or the supporting surface with the form of a truncated cone can also be a certain distance away from the sealing surface. In this context, the areas with the form of a truncated cone preferably each extend at least up to the area of the sealing ring projecting from the associated receiving groove.

If the pressurizing surface and the supporting surface enclose angles of the same magnitude with the sealing surface, which can particularly apply to the areas of said surfaces with the form of a truncated cone, the sealing ring can be inserted into

the associated groove in the correct position in both possible arrangements. For certain requirements, however, it can also be particularly expedient to design the sealing ring to be "asymmetrical", such that the pressurizing surface and the supporting surface enclose different angles with the sealing surface. In this context, the angle between the supporting surface and the sealing surface can be greater or smaller than the angle between the pressurizing surface and the sealing surface.

Pursuant to a first advantageous embodiment, the sealing ring according to the invention displays an essentially triangular cross-section.

According to a further advantageous embodiment, the sealing ring displays a transitional area between the pressurizing surface and the respective supporting surface, where the supporting surface and/or the pressurizing surface each preferably follow on directly from the sealing surface and, independently hereof, are preferably designed as lateral surfaces of a truncated cone, said transitional area preferably being designed as the lateral surface of a truncated cone with a comparatively small angular inclination relative to the sealing surface, or as the surface of a cylinder. In this way, the sealing ring can display an essentially trapezoidal cross-section, where the respective surfaces can each transition into each other via rounded areas or via sharp-edges areas. This makes it possible to increase the width of the sealing ring and, as a result, the size of the sealing surface, in particular.

According to a further embodiment, which is advantageous for specific applications, the above-mentioned transitional area between the pressurizing surface and the supporting surface is design in arched fashion, e.g. with an arch in the form of a segment of a circle, where the arch particularly points away from the sealing surface as an outward arch, i.e. is oriented in the radially inward direction in the case of a radially ex-

ternal sealing surface, and in the radially outward direction in the case of a radially internal sealing surface. In this context, the receiving groove can also be designed with a correspondingly arched groove base, or transitions of the groove base to the adjacent groove flanks, this not only avoiding notch effects, but also permitting optimum utilization of the groove depth, thereby obtaining optimum sealing effects of the sealing surfaces of the sealing ring.

The sealing surface of the sealing ring is preferably the surface with the greatest width referred to the cross-sectional view of the sealing ring, i.e. the hypotenuse in the case of an essentially triangular sealing ring, or, in the case of an essentially trapezoidal sealing ring, preferably the base surface with the greater length in the cross-sectional view.

For special applications, it can be advantageous to give the pressurizing surface and/or the supporting surface of the sealing ring an appropriate profile, so that, in the case of a flowing fluid medium, for example, a certain deflection of the flow of the fluid medium, preferably in the manner of a blade effect, is achieved, and/or an increased sealing effect of the respective surface. The sealing properties of the sealing ring can be improved in this way, particularly if the sealing ring is not pretensioned and undergoes expansion/compression under the pressure exerted by the fluid medium.

To facilitate radial expansion or compression of the sealing ring by a fluid medium, the circumference of the sealing ring can be divided almost completely or throughout. This ensures that only slight forces oppose radial motion, even in the event of radial expansion/compression of the sealing ring. Almost complete division can be present if adjacent areas of the sealing ring are still connected to each other by a film hinge or the like. The dividing area can be designed in the manner of a "lock" or a labyrinth seal, to which end the sealing ring is

provided with stepped incisions, which can display the form of a Z or a W, for example. The dividing area thus displays comparatively great tightness owing to the laterally overlapping areas of the sealing ring, which are located one behind the other in the direction in which the sealing ring is pressurized with fluid.

The sealing ring can consist of plastic, particularly a thermoplastic material, which can, for example, be processed by an injection molding process, or as powder in a direct molding process. This kind of choice of sealing ring material is particularly possible because, by adjusting the contact pressure of the sealing ring against the component with the sealing ring receiving groove, or against the corresponding component to be sealed, the contact forces of the sealing ring can be adjusted, and thus also the relative motion of the sealing ring in relation to the respective component. Thermoplastic materials of this kind can, in particular, be PAI, PAEK, PEEK, PI, PTFE or other suitable plastics. The sealing ring preferably does not consist of an elastomeric material.

The sealing ring preferably consists of a plastic material displaying elastic elongation of ≤ 75% or ≤ 50%, preferably ≤ 30%, particularly preferably ≤ 20%, at room temperature. The elastic elongation under the specified conditions should, however, generally not be less than 2% or 5%. In particular, the plastic material can display an elongation at break of ≤ 75% or ≤ 50%, preferably ≤ 30%, possibly ≤ 20%, at room temperature (determination according to ASTM or DIN standards, e.g. DIN 53504). It goes without saying that an elastic elongation or elongation at break of the material of > 50% may be acceptable for certain applications. The elongation at break should, however, be > 2% or > 5% or > 10%.

The object of the invention is furthermore a sealing arrange-

ment, with a sealing ring according to the invention and a component receiving the sealing ring in a groove without undercut, where the groove displays a supporting flank and a pressure-side flank, these being respectively located opposite the supporting surface and the pressurizing surface of the sealing ring. In this context, the sealing ring supporting surface can be brought into contact with the supporting flank in sealing fashion over part of its surface, and particularly over its whole surface, preferably around the entire circumference.

To achieve not only advantages in terms of production engineering, but particularly also a high sealing effect even when only little design height is available, the pressure-side flank and/or the supporting flank of the groove enclose an angle of < 90° with the sealing surface of the sealing ring or the envelope of the open groove flank, where the enclosed angle can be < 80° to 75° and > approx. 20°, preferably approx. 30° to approx. 60°, particularly preferably approx. 45°. Furthermore, a gap is provided, at least between the pressurizing surface of the sealing ring and the pressure-side groove flank, into which a fluid medium, such as a gas or a liquid, to be provided on the pressure side of the sealing ring can flow, pressing the sealing ring against the supporting flank or the corresponding component. The pressure force of the sealing ring on the respective component can, where appropriate, be supported by pretensioning of the sealing ring, or it can, at least under certain conditions of the respective machine, be generated predominantly or exclusively by the pressure force of the fluid medium. In this context, the intended conditions of the machine are, for example, the conditions of idling, low-load or normal-load operation. The sealing ring thus acts as a dynamically stressed component and develops its intended sealing effect at least partially, or virtually completely, as a result of the pressure force of the fluid medium, at which the sealing ring can be expanded or compressed towards its sealing surface.

The gap between the sealing ring and the pressure-side flank can extend merely over the lateral pressurizing surface, which can, for example, be designed as the lateral surface of a truncated cone, although the gap can also extend farther, into the transitional area between the supporting surface and the pressurizing surface of the sealing ring, or over the entire transitional area, such that the sealing surface is additionally pressed against the component to be sealed by the pressure of the fluid medium.

The sealing ring is preferably accommodated almost entirely in the respective groove, to which end it can preferably protrude by less than one-third of its radial thickness, e.g. less than 10% or less than 5%, from the groove at the height of the supporting flank and/or the pressure-side flank. The protruding area of the sealing ring must be adapted to the respective distance between the components to be moved relative to each other, such as the clearance to be provided between piston and piston-pin bush, shaft and shaft guide or the like, for operation of the corresponding machine as intended. The projecting area can, for example, be in the region of 1 mm or less, e.g. in the region of 1/4 mm or 1/10 mm.

The axial extension of the transitional area between the supporting surface and the pressurizing surface of the sealing ring can be less than 80%, 50%, or less than 10% of the axial extension of the sealing ring or the width of the sealing surface, or more than 10%, 20%, or more than 50% of the axial extension of the sealing ring or the width of the sealing surface.

The cross-sectional contour of the supporting flank of the groove preferably corresponds to the cross-sectional contour of the corresponding supporting surface of the sealing ring, such that the supporting surface and the supporting flank can be brought into contact with each other over part or the whole of

their surface in the respective sealing arrangement, particularly at maximum expansion or compression of the sealing ring in the direction of the sealing surface, particularly in all states of expansion or compression. The supporting surface of the sealing ring can preferably be brought into contact with the supporting flank of the groove without any gap.

The pressure-side gap furthermore preferably displays a constant gap width, which can, for example, be in the region of 1 mm or less, less than 0.5 mm, or less than 1/10 mm. It goes without saying that the gap width must be selected suitably in accordance with the respective fluid medium, the respective operating pressure and the sealing ring diameter.

The gap width is preferably less than/equal to the radial projection of the sealing ring from the groove on the side of the supporting flank and/or the pressure-side flank, which can, in this context, preferably be less than 20% or 10%, where appropriate also less than 5%, of the radial thickness of the sealing ring.

The groove base, or the transitional areas of the groove base, is or are preferably of rounded or arched design towards one or both of the adjacent groove flanks, this avoiding sharp-edged transitions.

The arrangement according to the invention is preferably envisaged for sealing a shaft against a shaft guide, where the sealing ring can contact the component opposite the groove with or without pretension. As a result of adjusting the contact pressure against the component to be sealed by means of suitable inclination of the pressurizing surface, the sealing ring can be fixed in position relative to a shaft guide, which can be designed as a housing in particular, largely or completely avoiding rotary motion of the sealing ring relative to the shaft guide owing to the respective contact force. This makes

it possible to design the sealing ring as a plastic component and/or to manufacture the housing from a light metal material, particularly an aluminum material, which displays only little wear resistance.

One particularly advantageous field of application for the sealing arrangement according to the invention is its use in automatic transmissions for sealing at least one oil passage against transmission components, particularly hollow shafts.

Another particularly advantageous field of application is that as a piston ring in a piston engine, which can particularly be a combustion engine, a steam engine or a reciprocating pump. In this context, the sealing ring can be provided as a piston ring, particularly also at a distance from the piston head, where the depth of the pressure-side groove flank can correspond to the depth of the supporting flank. In this context, at least one further piston ring, which can be designed according to the invention or of a different design, can also be located between the piston ring according to the invention and the piston head.

In the sealing arrangement according to the invention, with the sealing ring as a piston ring, the contact pressure of the sealing ring on the cylinder wall is thus controlled by the pressure in the cylinder chamber. This makes it possible to dispense with permanent external pretensioning of the piston ring, or the provision of supporting springs or further piston rings that press the piston ring according to the invention against a groove flank or the cylinder, although these can be provided for certain applications.
It goes without saying that, given a sufficiently short piston stroke, a sealing ring according to the invention can, where appropriate, also be located in the respective cylinder accommodating the piston.

It goes without saying that the provision of a gap between the sealing ring and the component accommodating the sealing ring in a groove, into which a fluid medium can flow for pressurizing the sealing ring, is a particularly preferred embodiment of a sealing arrangement, but the sealing ring according to the invention can also be used in sealing arrangements without a gap of this kind for certain applications.

An example of the invention is described below and explained on the basis of the drawings. The drawings show the following:

Figure 1a A schematic cross-sectional representation of a sealing ring according to the invention and a first component with a receiving groove for the sealing ring,

Figure 2a-c Schematic representations of alternative embodiments of sealing rings according to the invention,

Figure 3a-c Schematic representations of sealing rings according to the invention in receiving grooves of a first component, in sealing contact with a second component,

Figure 4 Schematic representations of a sealing ring according to the invention in a shaft seal, where the receiving groove of the sealing ring is located in the shaft (Figure 4a) or the shaft guide (Figure 4b),

Figure 5 A schematic representation of a sealing ring in a piston arrangement,

Figure 6a-f Schematic representations of the dividing area of a sealing ring according to the invention, de-

signed as a labyrinth seal,

Figure 7a-d Schematic representations of the dividing area of sealing rings according to the invention.

Pursuant to Figure 1, sealing ring 1 according to the invention displays a radially external sealing surface 2, which, as the surface of a cylinder, is positioned with a surface normal perpendicular to the central longitudinal axis of the sealing ring, or the longitudinal axis or axis of displacement 3 of component 4, which receives the sealing ring in a groove 5. In this context, the full area of sealing surface 2 is in contact with component 6 to be sealed, where components 4 and 6 can be capable of rotary movement or axial displacement relative to each other. In this context, the thickness of the sealing ring is less than the axial extension or width of the sealing ring in direction 3, as a result of which the fluid medium can achieve a high sealing effect of the sealing ring.

Located laterally to sealing surface 2, the sealing ring displays a supporting surface 7 and an opposite pressurizing surface 8, each of which is inclined relative to sealing surface 2 and encloses an angle of approx. 45° with it. The sealing ring is of symmetrical design in this context. Provided between pressurizing surface 8 and adjacent pressure-side groove flank 9 is a gap 10, into which a fluid medium, such as a gas or a liquid, can flow from the left-hand side in the drawing. Owing to the inclined pressurizing surface, the fluid medium exerts a pressure F_P perpendicular to the pressurizing surface, which results in a radial sealing force F_D of sealing surface 2 of component 6 on the sealing ring, and a supporting force F_S of supporting flank 11 of the groove on the sealing ring. In this context, Figure 1b shows the forces acting externally on the sealing ring in the form of a diagram of forces. As a result, the sealing ring is pressurized against both components 4 and 6 by the fluid medium, forming a seal. In this context, pressurizing surface 8 and supporting surface 7 are each designed as lateral surfaces of a truncated cone that laterally border the

sealing ring over its entire radial thickness. Where appropriate, the sealing ring can also be slightly rounded in the area of radial boundary A and/or radial boundary B, or it can be provided with an axially projecting sealing lip.

The width of gap 12 existing between components 4 and 6, which move relative to each other, roughly corresponds to one-tenth of the thickness of the sealing ring, the width of gap 10 corresponding to roughly half the width of gap 12. It goes without saying that the gap widths can also be dimensioned differently, independently of each other. According to the practical example, gap 10 extends over the entire lateral border or radial extension of the sealing ring. In this context, supporting surface 7 of the sealing ring is in flat contact, more precisely full contact, with supporting flank 11 of the groove. In this context, both surfaces are in flat contact, more precisely full contact, with each other in installed position between components 4 and 6 in every possible expansion/compression condition of the sealing ring.

As a result of the described design of the sealing ring and the groove, not only can the groove be manufactured particularly simply in terms of production engineering, but the design of the sealing ring can also be adapted to widely differing requirements with little design-related effort by changing the inclination of the supporting surface and/or the pressurizing surface of the sealing ring and the associated groove flanks.

Figure 2a shows a schematic representation of a sealing ring according to the invention, where pressurizing surface 8 and supporting surface 7 enclose different angles with sealing surface 2, in which context other angles can also be realized. In certain applications, supporting surface 7 can also be at a steeper angle to sealing surface 2 than pressurizing surface 8.

Figures 2b and 2c show sealing rings with transitional areas 20

between supporting surface 7 and pressurizing surface 8, which are here again designed as lateral surfaces of a truncated cone. Transitional areas 20 are designed as surfaces of a cylinder here, although they can, for example, also be designed as lateral surfaces of a truncated cone, which then preferably enclosed a much smaller angle with the sealing surface than lateral boundary surfaces 7, 8 of the sealing ring.

The transitional areas between supporting surface 7 and/or pressurizing surface 8 pursuant to Figures 1 and 2a, or between the lateral boundary surfaces and transitional area 20, can, as indicated by the broken line, also be arched where appropriate. The cross-sectional form of the groove in the area of the pressurizing surface, the supporting surface and/or the transitional area between them, preferably corresponds to the cross-sectional form of the corresponding seal, apart from a gap for the fluid medium, where appropriate.

Figure 3a shows a schematic representation of sealing ring 1 located between components 4 and 6, where the supporting surface and the pressurizing surface meet in area 30 of the sealing ring in sharp-edged manner, or with very slight rounding. Thus, gap 10 and, consequently, pressurizing surface 8 of the sealing ring extend over the height of the triangular cross-section of the sealing ring.

Figure 3b shows a sealing ring with an arched transitional area 31, where gap 10 and, consequently, also pressurizing surface 8 also extend into rounded transitional area 31 of the sealing ring. Accordingly, groove 5 displays an arched groove base 32. In this context, gap 10 tapers towards groove base 32. As a result of the extension of gap 10, into which pressurized fluid medium can flow from the pressure side (on the right in Figure 3), the sealing ring is additionally pressed radially outwards against component 6, forming a seal.

Pursuant to Figure 3c, the sealing ring is of asymmetrical design, and pressurizing surface 8 is arranged more steeply to sealing surface 2 than supporting surface 7. Transitional area 33 between the supporting surface and the pressurizing surface of the sealing ring, which is located opposite sealing surface 2, is likewise designed as the surface of a cylinder, where gap 34 extends over the entire transitional area 33 of the sealing ring. It goes without saying that the gap width at the level of transitional area 33 can also be smaller than at the level of pressurizing surface 8, or negligible in comparison with it, in order merely to permit pressurization of supporting surface 7 and supporting flank 11 without skewing.

Figures 4a and 4b show sealing arrangements according to the invention where, pursuant to Figure 4a, the component accommodating sealing ring 1 in groove 5 is designed as a shaft 4, and component 6 to be sealed is designed as a shaft guide. In this context, the shaft guide, which can constitute a housing, can also be a housing made of light metal, such as aluminum. Due to the fluid medium flowing into the gap, the sealing ring is pressed radially outwards and expanded slightly. The supporting surface of the sealing ring is arranged at such an angle to the pressure direction of the fluid, or to the longitudinal direction of the shaft, that the pressure force is sufficient to press the sealing surface of the sealing ring in sealing fashion against the shaft guide with relatively high force, such that, even if the shaft rotates, the sealing ring remains stationary, i.e. does not rotate, on the shaft housing due to static friction. Wear of the housing as a result of motion of the sealing ring relative to the housing is avoided in this way. Furthermore, even if the shaft rotates at high speed, pretensioning of the sealing ring can often be dispensed with because it is pressed against the sealing surface with sufficient force.

Where appropriate, the pressure conditions can thus be set by

means of the angle of the supporting surface in such a way that the ring "runs" in the groove of the shaft.

Figure 4b shows a sealing arrangement according to the invention, where sealing ring 1 is located in groove 5 of a component 4 designed as a shaft guide. As a result of fluid medium flowing into gap 10, sealing ring 1 is pressed radially inwards, undergoing slight compression, onto component 6 designed as a shaft. The shaft guide, or the housing accommodating sealing ring 1, can possibly again be made of light metal in this case. Again, the supporting surface of the sealing ring can be arranged at such an angle to the pressure direction of the fluid, or the longitudinal direction of the shaft, that the pressure force is sufficient to press the sealing surface against the shaft with sufficient force, where the sealing ring can remain stationary relative to the shaft or the shaft guide, where appropriate, or rotate relative to both components.

The shafts pursuant to Figures 4a and 4b can, where appropriate, perform rotary motion relative to the respective shaft guide. It goes without saying that, where appropriate, components 4 and 6 can also be designed as connecting rods mounted in corresponding guides.

Figure 5 shows a piston arrangement according to the invention, in which sealing ring 1 is located in a groove 5 of a piston 50, where groove 5 is located a distance away from piston head 51. Where appropriate, further sealing rings can also be located between sealing ring 1 according to the invention and the piston head. As a result of gas from pressure chamber 52 flowing into gap 10, which can be the combustion gas of a combustion engine, the steam of a steam engine, or a fluid to be conveyed by a reciprocating pump, such as a gas or a liquid, sealing ring 1 is pressed against piston cylinder 53, forming a seal.

It goes without saying that, in all the practical examples described, the sealing ring can contact the respective component to be sealed either without or with pretension, where the contact force can in each case be generated partly, predominantly or entirely by the fluid medium.

To facilitate expansion or compression of the sealing ring, it is preferably divided over its entire cross-section, as explained by way of example in Figures 6 and 7. Naturally, other designs are also possible for this purpose.

Pursuant to Figure 6, dividing area 60 of the sealing ring displays a first end 61 with a web 62, arranged in a central area, that engages a fork-like end 63 of opposite end area 64. The length of web 62 and receiving groove 65 is dimensioned such that they engage each other in every expanded or compressed position of the sealing ring in the respective sealing ring arrangement. Figures 6b and 6c show views of sealing surface 2 and of a lateral boundary surface 7, 8 of the sealing ring when the sealing ring is expanded. Figures 6d to 6f show sectional views of the sealing ring according to Figure 6b. The W-shaped labyrinth seal is capable of achieving the most extensive possible tightness, while facilitating expansion or compression of the sealing ring.

Figures 7a to 7c show modifications of labyrinth seals or "locks" in the dividing area of the sealing ring. According to Figure 7a, the labyrinth seal is designed in the manner of a double step with Z-shaped step arrangements. Figures 7b and 7c show variations of a "fork lock" pursuant to Figure 6, where center web 62 extends up to back 70 of the sealing ring, opposite sealing surface 2. Furthermore, below one or both partial areas, which are parts of supporting surface 7 and pressurizing surface 8, the center web displays step-shaped shoulders 71, 72, which can be provided with inclined surfaces, where appropriate. This avoids sharp-edged areas or steps on the sealing

ring, and damage to the sealing ring in the area of the edges. Furthermore, this avoids a kind of wedging of areas, such as fork-shaped areas 63 pursuant to Figure 6a or areas of a first step 70a pursuant to Figure 7a, which are supported in the direction of pressure by opposite areas of the other end of the sealing ring.

Pursuant to Figure 7c, starting from supporting surface 7 and/ or pressurizing surface 8 of the sealing ring, the areas of a center web or an internal step extend into the inside of the sealing ring with arc-shaped areas 74, 75. It goes without saying that the web or the fork areas of the other end of the sealing ring have a corresponding cross-sectional shape and corresponding contact surfaces. In this context, center web area 76 displays inward indentations 77 on both sides.

The step-shaped or arched areas can improve the "locking" of the sealing ring ends when pressurized, the arches simultaneously preventing skewing in the event of expansion/compression of the sealing ring.

Sealing ring and sealing ring arrangement

List of reference numbers

1	Sealing ring
2	Sealing surface
3	Longitudinal axis/Axis of rotation
4	Component
5	Groove
6	Component
7	Supporting surface
8	Pressurizing surface
9	Pressure-side groove flank
10	Gap
11	Supporting flank
12	Gap
20	Transitional area
30, 31, 33	Transitional area
32	Groove base
34	Gap
50	Piston
51	Piston head
52	Pressure chamber
53	Cylinder
60	Dividing area
61	First end
62	Web
63	Fork

64	Second end
65	Groove
70	Back
70a	Step
71, 72	Bevel
74, 75	Curved area
76	Center web
77	Arched indentation